



MARKSCHEME

SPECIMEN PAPER

PHYSICS

Higher Level

Paper 2

General Marking Instructions

Subject Details: Physics HL Paper 2 Markscheme

Mark Allocation

Candidates are required to answer ALL questions. Maximum total = [95 marks].

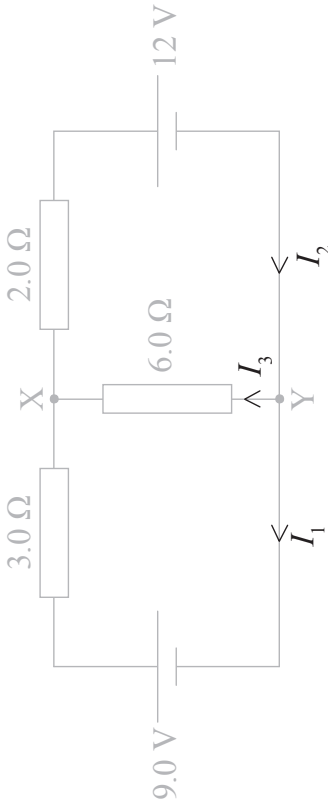
Markscheme format example:

Question		Answers	Notes	Total
4.	b ii	the displacement and acceleration ✓ are in opposite directions ✓	<i>Accept force for acceleration.</i>	2

- Each row in the “Question” column relates to the smallest subpart of the question.
- The maximum mark for each question subpart is indicated in the “Total” column.
- Each marking point in the “Answers” column is shown by means of a tick (✓) at the end of the marking point.
- A question subpart may have more marking points than the total allows. This will be indicated by “**max**” written after the mark in the “Total” column. The related rubric, if necessary, will be outlined in the “Notes” column.
- An alternative wording is indicated in the “Answers” column by a slash (/). Either wording can be accepted.
- An alternative answer is indicated in the “Answers” column by “**OR**” on the line between the alternatives. Either answer can be accepted.
- Words in angled brackets < > in the “Answers” column are not necessary to gain the mark.
- Words that are underlined are essential for the mark.
- The order of marking points does not have to be as in the “Answers” column, unless stated otherwise in the “Notes” column.
- If the candidate’s answer has the same “meaning” or can be clearly interpreted as being of equivalent significance, detail and validity as that in the “Answers” column then award the mark. Where this point is considered to be particularly relevant in a question it is emphasized by ***OWTTE*** (or words to that effect) in the “Notes” column.
- Remember that many candidates are writing in a second language. Effective communication is more important than grammatical accuracy.

12. Occasionally, a part of a question may require an answer that is required for subsequent marking points. If an error is made in the first marking point then it should be penalized. However, if the incorrect answer is used correctly in subsequent marking points then **follow through** marks should be awarded. When marking, indicate this by adding **ECF** (error carried forward) on the script. “ECF acceptable” will be displayed in the “Notes” column.
13. Do **not** penalize candidates for errors in units or significant figures, **unless** it is specifically referred to in the “Notes” column.

Question		Answers	Notes	Total
1.	a	use of suitable kinematic equation eg: $-48 = 48 - 9.81t$ ✓ $9.8 \langle s \rangle$ ✓	<i>Award [2] for a bald correct answer.</i>	2
	b	$0 = 48^2 - 2a8$ so $a = 144 \langle m s^{-2} \rangle$ ✓ $F_{net} = 480 \times 144 \langle = 6.9 \times 10^4 \rangle$ ✓ average force $\langle = 6.9 \times 10^4 + 0.47 \times 10^4 \rangle = 7.4 \times 10^4 \langle N \rangle$ ✓		3
	c	reaction force is zero ✓ because object and container fall at same rate ✓		2
	d	volume $= 120 \times \pi \times (3.5)^2 = 4620 \langle m^3 \rangle$ ✓ $n = \frac{0.96 \times \text{volume}}{(8.31 \times 300)} = 1.78$ ✓ number of molecules $= 6.02 \times 10^{23} \times n = 1.1 \times 10^{24}$ ✓		3
	d	yes because pressure is low ✓ and temperature is high/moderate ✓		2
	e	stopping distance $\langle \text{in polystyrene} \rangle / 8 \text{ m}$ ✓	<i>Do not accept distance unqualified.</i>	1
	e	gradient decreases as time increases before hitting the polystyrene ✓ lower maximum ✓ graph must go on longer before deceleration ✓ same total area by eye ✓	<i>Accept a graph reaching terminal speed.</i>	3 max

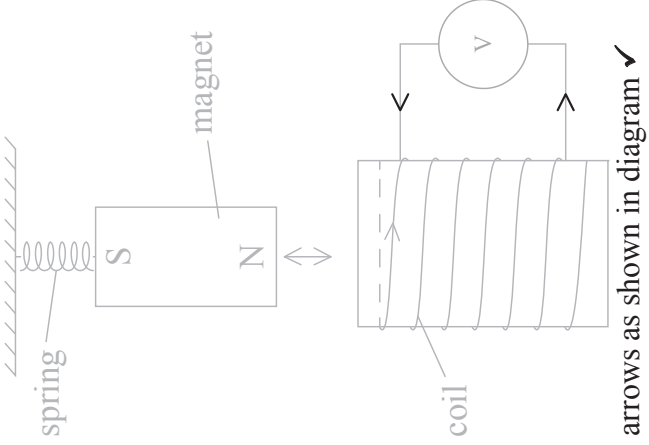
Question	Answers	Notes	Total
<p>2. a</p>	<p>Kirchhoff 1 applied correctly ✓ Kirchhoff 2 applied to one loop correctly ✓ Kirchhoff 2 applied to a second loop correctly ✓ simultaneous equations constructed correctly to give answer ✓ direction of current stated towards X ✓</p>  <p>eg: $I_2 = I_1 + I_3$ $9 = 3I_1 - 6I_3$ $12 = -2I_2 - 6I_3$ $9 = 3I_2 - 3I_3 - 6I_3$ $36 = -6I_2 - 18I_3$ $18 = 6I_2 - 18I_3$ $54 = -36I_3$ $I_3 = -1.5 \text{ A}$</p>	<p>Allow ECF from incorrect sign in the last marking point.</p> <p>Negative sign means current flow is from X to Y.</p>	4 max
b i	potential difference = $\langle 1.5 \times 6.0 \Rightarrow 9.0 \text{ V} \rangle$ ✓		1
b ii	$\langle X$ is higher \rangle because $\langle \text{conventional} \rangle$ current is flowing / positive charge would flow from X to Y ✓		1

Question		Answers	Notes	Total
3.	a	correct curvature starting at 0,0 ✓ asymptotic to 6.0 <V> ✓		2
	b	i use of $V = V_0 e^{-\frac{t}{RC}}$ ✓ $V = 6.0 e^{-\frac{6.3 \times 10^{-3}}{3300 \times 4.7 \times 10^{-6}}}$ ✓ 4.00 <V> ✓		3
	b	ii $Q_{\text{initial}} = \langle 6.0 \times 4.7 \times 10^{-6} \rangle \Rightarrow 28.2 \langle \mu\text{C} \rangle$ <i>OR</i> $Q_{\text{final}} = \langle 4.00 \times 4.7 \times 10^{-6} \rangle \Rightarrow 18.8 \langle \mu\text{C} \rangle$ ✓ $\Delta Q = 9.4 \langle \mu\text{C} \rangle$ ✓	Allow ECF from (b)(i).	2
	b	iii battery capacity = $0.55 \times 3600 = 1980 \text{ C}$ ✓ $\langle \frac{1980}{9.4 \times 10^{-6} \times 3600 \times 24 \times 365} \rangle \Rightarrow 6.7 \text{ year}$ ✓	Allow ECF from (b)(ii).	2
	b	iv V values <all> double ✓ energy proportional to V^2 so $\times 4$ ✓		2

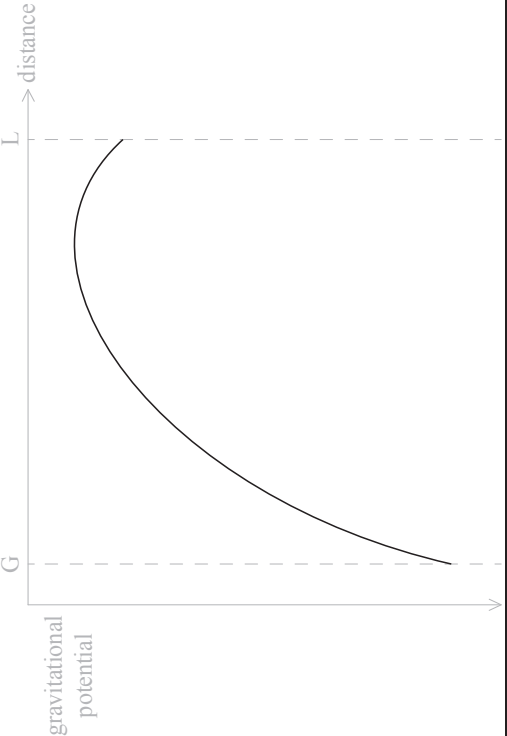
Question		Answers	Notes	Total
4.	a	<p>travelling sound wave <is reflected at the barrier and> travels in opposite direction to original wave ✓</p> <p>mention of interference/superposition ✓</p> <p>minima caused by destructive interference ✓</p> <p>maxima caused by constructive interference ✓</p> <p>OR</p> <p>travelling sound wave <reflects at the barrier and> travels in opposite direction to original wave ✓</p> <p>reflected wave superposes with original wave ✓</p> <p>forming a standing wave ✓</p> <p>maxima are positions of antinodes, minima are positions of nodes ✓</p>		4
	b	<p>i</p> <p>recognition that 3.5 wavelengths are covered ✓</p> <p>0.29 <m> ✓</p>		2
	b	<p>ii</p> <p>measure each position of several minima/maxima using a ruler ✓</p> <p>use data to determine mean wavelength ✓</p> <p>measure frequency of waves using eg: oscilloscope/frequency meter/electronic guitar tuner ✓</p> <p>use of $c = f\lambda$ ✓</p>	Accept look up wave frequency or read from apparatus.	3 max

Question	Answers	Notes	Total
5. a i	power = $\langle \frac{7.5 \times 10^8 \times 100}{38} \rangle \Rightarrow 1.97 \times 10^9 \langle \text{J s}^{-1} \rangle \checkmark$		1
a ii	$\frac{1.97 \times 10^9}{35} \checkmark$ 56 \checkmark MJ kg ⁻¹ \checkmark		3
b	plentiful supplies at present \checkmark pre-existing infrastructure \checkmark	<i>Accept easily portable, easily mined.</i>	2
c i	increased proportion of greenhouse gases in atmosphere \checkmark so more absorption of infrared by atmosphere \checkmark and extra energy radiated back to ground \checkmark	<i>Accept any named greenhouse gas.</i>	3
c ii	improved modelling <i>OR</i> greater data collection <i>OR</i> greater international collaboration \checkmark		1 max
d i	$\langle 235 + 1 - 148 - 85 \rangle \Rightarrow 3 \checkmark$		1
d ii	mass difference = $\langle 148.932 + 84.910 + (2 \times 1.009) - 235.044 \rangle \checkmark$ = 0.816 $\langle \text{u} \rangle \checkmark$ 760 MeV \checkmark	<i>Allow ECF from (d)(i).</i>	3
d iii	neutrons emitted from uranium at high speed \checkmark high speed neutrons do not cause fission \checkmark neutrons collide with moderator atoms \checkmark and therefore lose energy/speed before re-entering fuel rods \checkmark		3 max

Question		Answers	Notes	Total
6.	a	force of gravity is proportional to the product of <point> masses ✓ and inversely proportional to distance between centres squared ✓		2
	b	force = $\left\langle \frac{Gm_1m_2}{r^2} \right\rangle = \left\langle \frac{6.67 \times 10^{-11} \times 47 \times 0.73}{(1.25 \times 10^{-1})^2} \right\rangle$ ✓ 0.15 <μN> ✓		2
	b	doubling radius increases mass of spheres by $\times 8$ ✓ so mass product increased by $\times 64$ ✓ doubling radius increases separation by factor of 2 hence r^2 by 4 ✓ overall effect is increase in force by $\times 16$ ✓ same time period for any amplitude of swing ✓		4
	c			1

Question		Answers	Notes	Total
7.	a	<p>gradient calculation attempted at $t=0$ <i>or</i> 0.5 1.0 ✓ evidence of including number of turns and area ✓ 3.2 mV ✓ answer expressed to two significant figures only ✓ cosine or negative cosine wave ✓ peak value double answer to part a ✓ period = 0.5 s ✓</p>	<p>Allow 3.0 mV to 3.4 mV.</p>	4
	b			3
	c	 <p>arrows as shown in diagram ✓ identifies north pole at top of coil ✓ uses stated direction rule to link induced north pole to current direction ✓</p>		1
	c	ii	<p>Allow answer in terms of Lenz's law or energy considerations.</p>	2

Question		Answers	Notes	Total
8.	a	force acting on ✓ unit mass ✓		2
	b	$\frac{GM_e}{x^2} = \frac{GM_m}{y^2}$ ✓ $\frac{x}{y} = \sqrt{\frac{M_e}{M_m}} = \sqrt{81} = 9$ ✓		2
	b	for the Moon $V = \left\langle \frac{-GM}{r} \right\rangle = -2.9 \langle \text{MJ kg}^{-1} \rangle$ ✓ for the Earth $\left\langle - \right\rangle 1.1 \langle \text{MJ kg}^{-1} \rangle$ ✓ total gravitational potential = $-4.0 \langle \text{MJ kg}^{-1} \rangle$ ✓		3
	b	graph rises close to but below zero ✓ falls to Moon ✓ from point much closer $\langle 10\% \text{ of way} \rangle$ to Moon than Earth ✓		3



Question		Answers	Notes	Total
9.	a	<p>there is a minimum energy required equal to the total mass of particles created OR reference to $\Delta E = \Delta m c^2$ and $\Delta m = 2m_e$ ✓ energy of photon = hf <so there is also a minimum frequency> ✓</p>	<i>Both needed.</i>	2
	b	<p>minimum energy = 1.02 <MeV> ✓ $= 1.63 \times 10^{-13}$ <J> ✓ 2.5×10^{20} <Hz> ✓</p>		3
	c	<p><both energy and> momentum must be conserved in the interaction ✓ nucleus absorbs the momentum <to allow the interaction to occur> ✓</p>		2